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ARE ARTICULAR CARTILAGE LESIONS AND MENISCUS TEARS PREDICTIVE OF IKDC, KOOS, AND MARX ACTIVITY LEVEL OUTCOMES AFTER ACL RECONSTRUCTION? A 6-YEAR MOON COHORT STUDY

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Purpose: Identifying risk factors for inferior outcomes after ACL reconstruction (ACLR) is important for prognosis and future treatment. The goal of this study was to analyze a sufficiently large enough cohort to evaluate whether articular cartilage and meniscal variables are predictive of three validated sports outcome instruments. We hypothesized that articular cartilage lesions and meniscus tears/treatment would be predictors of the IKDC, KOOS (all 5 subscales), and Marx Activity Level at 6 years after ACLR.
Methods: From 2002-2004, 1411 ACLR subjects were prospectively enrolled and followed longitudinally with the IKDC, KOOS, and Marx completed at entry, 2 and 6 years. A logistic multivariable model consisted of patient demographics, surgical technique variables, and articular cartilage injuries and meniscus tears/treatment for determining the predictors (risk factors) of IKDC, KOOS, and Marx at 6 years.
Results: We completed a minimum follow-up on 93% (1307/1411) of our cohort at 6 years. Baseline results included 56% male, median age of 23 years, 75% involved in non-contact injury mechanism, articular cartilage pathology (MFC-25%, LFC-20%, MTP-6%, LTP-12%, patella-20%, and trochlear-9%), and meniscal pathology (medial-38%, lateral-46%).
Both articular cartilage lesions and meniscal tears significantly predicted 6 year outcomes on IKDC and KOOS (Table 1). Grade 3 or 4 articular cartilage lesions in various compartments (excluding patella) significantly reduced IKDC and KOOS scores at 6 years. Figure 1 focuses on IKDC and demonstrates worse outcomes with chondral injuries on the MFC, MTP, and LFC. Likewise, the KOOS was negatively affected by cartilage injury. The sole significant predictor of reduced Marx activity was the presence of a grade 4 lesion on the MFC.
Lateral meniscus repairs did not correlate with inferior results, but medial meniscus repairs predicted worse IKDC and KOOS scores. Lateral meniscus tears left alone significantly improved prognosis. Small partial meniscectomies (<33%) on the medial meniscus fared worse, but conversely, larger excisions on the lateral meniscus (>50%) improved prognosis.
Analogous to previous studies, other significant predictors of worse outcome scores were lower baseline scores, higher BMI, lower education level, smoking, and revisions.

Table 1
Significant Predictors of Each Outcome Scale at 6 Years (p values)

Structure	IKDC	KOOS					Marx
		Symptoms	Pain	ADL	Spts/ Rec	QOL	
MENISCUS							
–Medial	0.003	0.001	0.001		0.004	0.025	
–Lateral	0.027	0.001	0.002	0.001	0.001	0.024	
ARTICULAR CARTILAGE							
–MFC	0.012		0.017			0.002	0.05
–LFC	0.002	0.029					
–MTP	0.002	0.033	0.024		0.02	0.029	
–LTP			0.037				
–Patella							
–Trochlea				0.031			

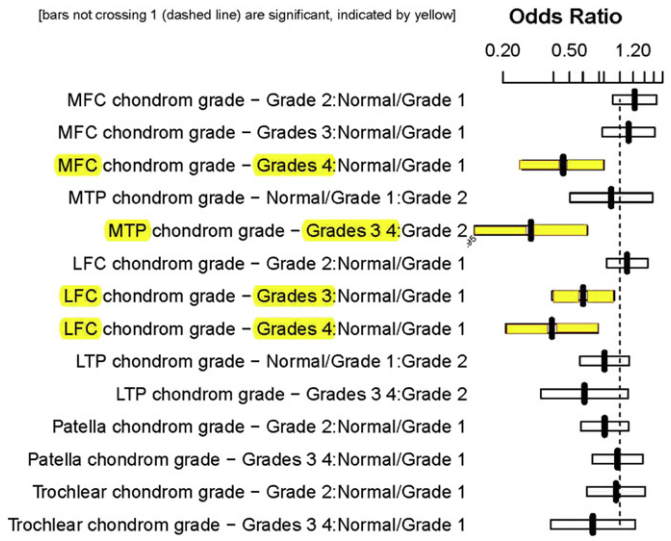

Figure 1. Articular Cartilage Predictors of IKDC at 6 Years (OR +/- 95% CI).

Conclusions: Both articular cartilage injury and meniscal tears/treatment at the time of ACLR were significant predictors of both IKDC and KOOS scores at 6 year follow-up. Similarly, having a grade 4 MFC lesion significantly reduced a patient's Marx activity level score at 6 years.

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SCORING HIP ABNORMALITIES USING MRI (SHAMRI): A NOVEL HIP WHOLE JOINT EVALUATION OF OSTEOARTHRITIS

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Purpose: Semiquantitative MRI whole joint grading systems have been proven to be powerful tools in assessing osteoarthritis progression and early detection especially in clinical research of the knee. However, for hip osteoarthritis MR grading systems have not been as well investigated, though there is an increasing research focus on the hip joint with the concept of FAI leading to early osteoarthritis and increasing treatment with hip arthroscopy over the recent years. The goals of this study were (i) to develop a novel semi-quantitative osteoarthritis evaluation scoring system for degenerative hip abnormalities using MRI designed for easy surgical correlation and (ii) to evaluate its reproducibility and validity.
Methods: Radiographs and non-contrast 3T MR images were acquired from hips of 94 patients (50 males and 44 females; aged 23 to 71 years). The standardized hip osteoarthritis outcome score (HOOS) questionnaire was used as clinical parameter and was acquired from 66 subjects. Intermediate weighted fast spin echo images were acquired in 3 planes. They were analyzed using a new whole-joint MRI scoring system evaluating cartilage, labrum, bone, synovial structures and tendons of the hip by 2 board-certified radiologists. Subregions of the joint were designated to maximize ease of scoring and practical correlation on surgery based on geographic zone method for hip arthroscopy. Articular cartilage, bone marrow and subcortical cysts were evaluated in 12 subregions. Cartilage loss was graded as either none, partial or full thickness. Labrum was scored based on morphology and complexity of tear. Bone marrow, subcortical cysts and greater trochanter tendinopathy were also semi-quantitatively graded. Intra- and interobserver reproducibility was measured on a random subset of 30 cases and 94 cases respectively, using Cohen's kappa statistics. Validity was tested by assessing correlation between Kellgren-Lawrence (KL), OARSI hip osteoarthritis grading and clinical parameters from HOOS. Oneway ANOVA analysis was used for KL grading and Pearson's correlation for OARSI and HOOS.
Results: Radiographic KL grading distribution was: KL 0=26, KL 1=33, KL 2=19, KL 3=14. Intra and inter-observer reproducibilities per single feature had K values between 0.68 to 0.82 and 0.56 to 0.96, respectively. Kappa values were lower for cartilage and synovial evaluation (less than 0.80) and higher for labral, bone marrow, synovial abnormalities and greater trochanter insertion tendinopathy (greater than 0.80). The overall percent agreement was above 0.80 for both intra and

interobserver reproducibilities. High associations between MRI and radiographic osteoarthritis scores were noted for both KL ($p = 0.0006$) and OARSI scores ($p<0.001$). The newly developed score was also highly correlated with clinical parameters, including total score and each subcategory of the HOOS questionnaire ($p < 0.0013$).

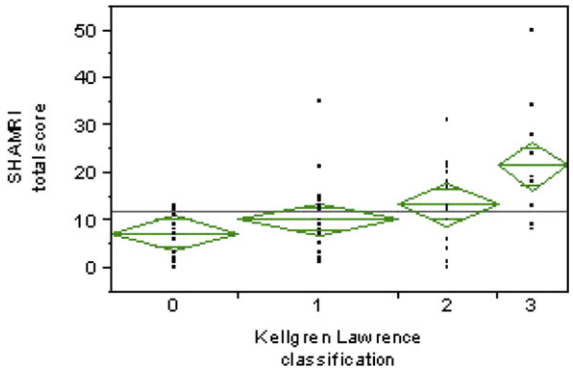

Figure 1. SHAMRI total score and Kellgren Lawrence grading.

Conclusions: The novel MRI evaluation system of hip osteoarthritis designed for practical application and easy surgical correlation showed high intra- and inter-observer reproducibility and high correlation with radiographic osteoarthritis and clinical parameters.

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BONE MINERAL DENSITY CHANGES FOLLOWING ANTERIOR CRUCIATE LIGAMENT RUPTURE

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Purpose: An anterior cruciate ligament (ACL) rupture is a common sports related injury in young people. A long-term consequence of an ACL rupture is the development of osteoarthritis (OA). The pathophysiology of an ACL rupture leading to evident knee OA still remains largely unknown. Previous studies showed a relation between high subchondral bone mineral density (BMD) in the tibia and risk of developing OA in the knee. In contrast, the BMD in the knee after an ACL rupture seems to be lower compared to the contralateral knee. The aim of this study is to determine differences in BMD between affected and contralateral knees in patients with an ACL rupture and if BMD changes occur during 2 years follow-up.
Methods: The KNALL (KNee osteoArthritis anterior cruciate Ligament Lesion) study is a prospective follow-up study in which 154 patients were included with an ACL rupture. The patients were included after the initial trauma up to 6 months and evaluated each year up to 2 years. Patients were treated operatively or non-operatively. Inclusion criteria were age between 18 and 45 years and an ACL rupture diagnosed by physical examination and MRI. Patients with previous ACL injury or meniscus or cartilage damage (diagnosed by an orthopaedic surgeon or sports physician); those with previous surgery of the involved knee; those with disabling co-morbidity; and those with already osteoarthritic changes on X-ray (Kellgren & Lawrence > 0) were excluded. Patients were recruited at three outpatient clinics of the department of orthopaedics in the Netherlands. At baseline, one year and two years follow-up BMD was measured for both knees using a DEXA scanner (anteroposterior views). Six regions of interest (ROI) were determined as follow: we outlined the contours of the femur and tibia by placing anatomical landmark points using the ASM toolkit software package. Using the anatomical landmark points we automatically extracted 6 ROIs: ROI 1 (medial), 2 (central), 3 (lateral) in the tibia and 4 (medial), 5 (central) and 6 (lateral) in the femur. The regions in the tibia were positioned just below the subchondral bone. The regions in the femur were positioned such that the medial and lateral ROI were placed inside the respective condyles. At the same visits questionnaires were filled in, physical examination, X-rays and MRI's were performed.
Results: For the DEXA scan analysis we included 141 patients with the following characteristics: 66 % was male, median age at baseline was 25.5 years (IQR 21.5 - 32.6), median body mass index was 23.7 kg/m2 (IQR 21.9 - 26.2), median preinjury Tegner activity score was 9 (IQR 7 - 9), median time injury to inclusion was 81 days (IQR 53 -122), 63 % was treated operatively and median time injury to surgery was 172 days (IQR 100.5 - 253).

Table 1
Overview of BMD values in all ROIs in affected and contralateral knee

	Mean BMD (g/cm^2) affected knee	Mean BMD (g/cm^2) contralateral knee
Baseline		
ROI 1/27 3	0.951/ 0.955/0.955	0.991/ 1.004/1.003
ROI 4/ 5/ 6	1.076/ 1.335/ 1.225	1.100/ 1.364/1.276
1 year follow-up		
ROI 1/2/3	0.921/0.899/0.904	0.982/0.988/0.987
ROI 4/ 5/ 6	1.028/1.300/ 1.192	1.108/ 1.390/ 1.281
2 years follow-up		
ROI 1/2/3	0.955/0.920/0.945	0.997/0.981/0.987
ROI 4/ 5/ 6	1.035/1.342/ 1.236	1.107/ 1.410/ 1.298

An overview of the results is given in table 1. At baseline, one year and two years follow-up the mean BMD values in all ROIs were significantly lower in the affected knee compared to the contralateral knee. The mean BMD values in all ROIs in the affected knee were significantly decreased after one year follow-up compared to baseline. Between follow-up 1 year and 2 years the mean BMD increased significantly in all ROIs excluding the medial femurcondyle in the affected knee. In the operatively treated patient group the BMD decrease was significantly larger than in the non-operatively treated group.
Conclusions: During two years after ACL rupture the BMD in the affected knee is lower compared to the contralateral knee. Patients treated operatively had a larger decrease in BMD than patients treated non-operatively.

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MINERALIZATION OF MENISCAL ENTHESIS IN OSTEOARTHRITIC KNEES

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Purpose: Meniscal entheses consist of a graded tissue interface which transitions from the ligament like structure of the main body meniscus to uncalcified fibrocartilage to calcified fibrocartilage to subchondral bone. Appropriate function of the menisci is dependent on entheses integrity. Because mineralization gradients dictate mechanics of other soft-tissue-to-bone insertion sites in the body, it is hypothesized that the graded mineralization of meniscal entheses may similarly influence meniscal mechanics. Meniscal extrusion occurs when the meniscal attachments become weakened and the meniscus extends beyond the tibial margin. This extrusion is a precursor of osteoarthritis (OA). The aim of this study was to assess changes in mineralization of meniscal enthesis that may occur in end-stage OA.
Methods: Healthy tissue (n=3) was obtained from human cadaveric donors and end-stage OA tissue (n=3) was obtained from patients undergoing total knee arthroplasty. Meniscal attachments (medial anterior/posterior and lateral anterior/posterior) were excised from the tibial plateau and scanned via micro-computed tomography (Sanco μCT 80). Mineral density measurements were taken across each enthesis, from the tidemark to the beginning of trabecular bone, using Image Processing Language (Scanco Medical AG). A custom Matlab script was used to identify the area of mineralization and average mineralization values. The thickness of the mineralized zone was calculated by assessing the number of data points over which the initial mineralization peak occurred. Student's t-tests were performed to compare thickness and average mineral density of healthy and OA entheses. Additionally, a sigmoidal Gompertz function was fit to the data and used to assess the points of initiation of mineralization, the mineralization growth rates, and the peak mineralization values.
Results: Mineralized zones were significantly thicker in OA mensical entheses compared to healthy samples ($p < 0.05$) (Figure 1). Average bone mineral density was significantly greater for healthy meniscal entheses ($p < 0.05$) (Figure 2). The fit of the Gompertz function (Figure 3) indicated that the rate of mineralization increase across the tidemark was greater for OA samples.